NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

DECISION SUPPORT REQUIREMENTS FOR THE AVIATION MAINTENANCE MATERIAL CONTROL OFFICER

by

Bruce W. Brosch

December, 1997

Principal Advisor: William J. Haga
Associate Advisor: Donald R. Eaton

Approved for public release; distribution is unlimited

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1997	Master's Thesis

4. TITLE AND SUBTITLE
DECISION SUPPORT REQUIREMENTS FOR THE AVIATION MAINTENANCE MATERIAL CONTROL OFFICER

5. FUNDING NUMBERS

6. AUTHOR(S)
Brosch, Bruce W.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey, CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(maximum 200 words)*

This thesis evaluates NALCOMIS based upon maintenance management information requirements and highlights how NALCOMIS does not support the Maintenance Material Control Officer (MMCO) as an information system.

The Automated Maintenance Environment (AME) initiative currently in development will be capable of providing the MMCO with the information needed to improve maintenance management decisions. The overall result will be reduced aircraft lifecycle costs and improved operational availability. A concept of operations at the organizational maintenance level is presented to illustrate the AME concept.

The full implementation of AME will have a profound effect on Naval aviation maintenance processes. Recommendations for further research are presented.

14. SUBJECT TERMS
NALCOMIS, Automated Maintenance Environment, Aviation Maintenance

15. NUMBER OF PAGES
97

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFI- CATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

DECISION SUPPORT REQUIREMENTS FOR THE AVIATION MAINTENANCE MATERIAL CONTROL OFFICER

Bruce W. Brosch
Lieutenant Commander, United States Navy
B.S., University of Colorado at Boulder, 1986

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
December 1997

ABSTRACT

This thesis evaluates NALCOMIS based upon maintenance management information requirements and highlights how NALCOMIS does not support the Maintenance Material Control Officer (MMCO) as an information system.

The Automated Maintenance Environment (AME) initiative currently in development will be capable of providing the MMCO with the information needed to improve maintenance management decisions. The overall result will be reduced aircraft lifecycle costs and improved operational availability. A concept of operations at the organizational maintenance level is presented to illustrate the AME concept.

The full implementation of AME will have a profound effect on Naval aviation maintenance processes. Recommendations for further research are presented.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

A maintenance troubleshooter working in the nose wheel well of an S-3 Viking aircraft was killed when the landing gear collapsed, crushing the technician. This mishap resulted from several factors: failure to follow maintenance procedures outlined in the technical manual, failed communication between multiple parties, and a lack of control for the overall maintenance action (Alkon, 1996, pp. 36-37). Incidents such as this one do not occur on a routine basis. But they do happen often enough to serve as a painful reminder that humans are prone to error. If advanced applications of information technology were incorporated into the aviation maintenance process, mishaps such as this could be minimized.

There are information technology applications which can provide maintenance control with the visibility needed to effectively coordinate and communicate maintenance actions to technicians on the aircraft. Information technology also provides the availability of complete, easy to use, technical and procedural information at the aircraft. If these technologies were in use, the death of the S-3 troubleshooter may not have occurred.

Information technology is not a panacea, and it requires funding to implement new systems. Unfortunately, the austere funding environment in which the Department of Defense must operate, sometimes makes safety a secondary concern to program cost. In this case, information technology must be able to provide significant levels of cost savings to become an attractive option in the search for new efficiencies.

Adept aviation maintenance management will reduce lifecycle costs of an aircraft, decrease maintenance downtime, increase operational availability, and efficiently use maintenance resources without compromising safety. The squadron Maintenance Material Control Officer is the focal point of the daily maintenance management for a squadron of aircraft. Supported by an experienced maintenance control staff, the decisions made by this junior officer will impact the lifecycle costs of an aircraft, its availability, and the allocation of maintenance support assets.

B. OBJECTIVE

The objective of this thesis is to analyze the maintenance management decisions made by the Naval aviation squadron Maintenance Material Control Officer (MMCO); and evaluate the decision support provided by the Naval Aviation Logistics Command Information System (NALCOMIS). The Automated Maintenance Environment concept will also be studied to present potential maintenance process improvements.

The following research questions provide the framework for this thesis:

1. Primary: How effective is NALCOMIS in providing the information required by the organizational level MMCO?

2. Secondary:

a. What does the MMCO require of an information system to make effective aircraft maintenance management decisions?

b. What is currently under development to enhance the performance of NALCOMIS?

c. What technologies would produce greater management information for the MMCO?

C. METHODOLOGY

This research topic is presented from an aviation maintenance perspective. Research data was obtained from sources with a similar perspective. Activities from which data was collected include: NAVAIRSYSCOM (PMA-265), COMNAVAIRPAC (Aircraft Maintenance Programs and Policies), NAVSURFWARCENT (Carderock Division) and the Boeing Company (St. Louis, Missouri). Data collection was conducted by telephone conversations, electronic mail and on-site. Further data was obtained through conversations with Aviation Maintenance Duty Officers, Naval Aviators and Naval Flight Officers stationed at the Naval Postgraduate School, Monterey, California. These officers shared experiences spanning six aircraft communities in the Navy.

Thesis research also included a thorough study of the Naval Aviation Maintenance Policy, various program proposals and studies, and literature review. The author's experience as an Aviation Maintenance Duty Officer was also used in discussion of maintenance processes. This experience includes two tours in F/A-18 squadrons and one tour in an Aircraft Intermediate Maintenance Department, afloat.

II. OVERVIEW OF THE MAINTENANCE MATERIAL CONTROL OFFICER FUNCTION

A. DUTIES AND RESPONSIBILITIES

The aviation squadron maintenance material control officer (MMCO) comes from a wide range of aviation maintenance backgrounds. The Aviation Maintenance Duty Officer (AMDO) is typically a college graduate and may not have prior enlisted experience. AMDOs attend the Naval Aviation Maintenance Program Indoctrination course for extensive training in naval aviation maintenance policy and management. The new officer receives training on the duties and responsibilities of the MMCO.

The Naval Aviation Maintenance Policy (NAMP) describes the responsibilities of the maintenance material control officer as; "...the overall productive effort and material support of the department..." (CNO, 1995, Vol. I, para. 11.6.2). The MMCO is the "bridge" within the squadron organization who translates operational commitments into maintenance priorities. Throughout each day, the MMCO keeps the maintenance and operations officers informed of the current readiness status of squadron aircraft. Along with this status, the MMCO gives inputs as to what operational objectives can be achieved given the required workload of the maintenance personnel.

The MMCO stays informed on the production schedule status through continuous communication with the Maintenance Master Chief Petty Officer (MMCPO). It is important that the MMCO maintain an awareness of how well the maintenance technicians are coping with their workload, and to know if production priorities are realistic. Additionally, the MMCO must ensure the squadron's support requirements are met through effective communication with the Wing, Supply, and the Intermediate Maintenance Activity.

The responsibilities of the MMCO may be classified into five general functional areas; personnel, support, configuration management, reports processing and production management. Appendix A details the specific responsibilities in accordance with the NAMP.

The production effort of any squadron maintenance department hinges upon the personnel of the maintenance workcenters. In order to effectively coordinate the production effort, the MMCO requires knowledge of workcenter manning levels and critical qualifications of maintenance personnel. This information is recorded in the squadron's Monthly Maintenance Plan which the MMCO is responsible for assembling. The MMCO must work with the Assistant Aircraft Maintenance Officer (AAMO) regarding training requirements or manpower deficiencies. Carrying out the coordination of the department workload necessitates that the MMCO have access to personnel information regarding the maintenance qualification of technicians.

Coordinating external support resources to the squadron are critical to the production control process. The MMCO must be in communication with the Type Wing/ Carrier Air Wing Maintenance Officer, Supply Department, and the Aircraft Intermediate Maintenance Department (AIMD) to ensure squadron maintenance requirements have the resources to repair aircraft. These resources range from funding to technical assistance. These relationships will be discussed further in the next section.

Maintaining the configuration management program is one of the most challenging responsibilities of the MMCO. The complexity of modern military aircraft systems and the increasing rate of technological advances, results in no two aircraft being exactly the same. Aircraft of the same model will not have identical components, software or engineering modifications. The safety of the flight crews and maintenance technicians depends upon the ability to track the exact configuration of every aircraft. Complete logistical support of a particular aircraft also depends upon accurate tracking of configuration. Cannibalization actions, technical modifications, software changes and individual component modifications add up to hundreds of items to track for each aircraft.

Maintaining complete accuracy over a large, rapidly changing volume of information is a demanding requirement for the MMCO and the maintenance control staff. Physical modifications to the aircraft, changes to avionics software and tracking of the serialized components used on an aircraft all fall under the realm of configuration management. Technical directives are the means by which changes to a type aircraft configuration are promulgated. The sophisticated technical nature of military aircraft results in the controlling of hundreds of technical directives for any given aircraft, many of which directly affect safety of flight. The MMCO is responsible for this program, and must ensure accurate records of technical directives are maintained on every aircraft in the squadron.

Screening and processing various status reports and administrative requirements comprise 50%-70% of the MMCO's workload. Such items include aircraft logbooks, weight and balance records, engine logbooks, engine transaction reports, budget reports, aircraft status reports, responses to technical directive screenings and daily validation of supply status reports. Other recurring administrative requirements include the review and processing of maintenance instructions and the monthly maintenance plan. Many of these reports and documents are primary sources of readiness information for supporting activities such as the Supply department, Carrier Air Wing and the Type Wing; so any inaccuracies become magnified as strategic decisions are based upon what the squadron reports.

Production management is the activity which transforms resources into goods and services (Heizer and Render, 1996,p. 4). In the case of the squadron maintenance department, various resources such as personnel, support equipment and repair parts are being transformed to provide the required number of aircraft which are ready to fly their intended mission. Daily requirements of the flight schedule must be met to fulfill operational demands. Scheduled (or preventive) maintenance must be coordinated with daily flight schedule demands to ensure the continued performance reliability of squadron aircraft. Any neglect of short term maintenance requirements will eventually incur negative effects in terms of long term readiness, availability and life cycle costs. The successful MMCO must maintain an effective balance of completing preventive and unscheduled maintenance requirements while providing adequate numbers of available aircraft for operational demands.

The MMCO is under a significant amount of pressure to fulfill the duties required of the position. Coordination of numerous resources and demands are necessary to meet operational commitments while maintaining squadron aircraft in reliable condition. Production plans differ each day in order to adapt with the uncertainties of maintenance requirements. Decisions must usually me made rather quickly to keep pace with a fast-moving operational environment. These decisions will usually lingering effects on the operational readiness of the squadron. Finally, at the end of each day, the performance of the MMCO is reflected by the percentage of sorties completed on the flight schedule.

B. ORGANIZATIONAL RELATIONSHIPS

The decisions of the maintenance material control officer are not made in isolation. The MMCO must coordinate the maintenance production effort with various operational requirements and environments. This section will discuss the organizational relationships of the maintenance material control officer's environment within the squadron and amongst support organizations of the type wing, carrier air wing, supply department and AIMD.

A typical tactical aviation squadron in the Navy consists of four departments; safety, administration, operations and maintenance. Maintenance has the greatest interaction with the operations department, since operations formulates the flight schedule. The maintenance department also has the majority of the squadron personnel assigned. Any personnel issues involving squadron enlisted personnel will have the greatest effect on the maintenance department. Within the maintenance department, the MMCO falls under the Aircraft Maintenance Officer and the Aircraft Assistant Maintenance Officer in the chain of command (Figure 2.1).

The type wing maintenance officer provides the resources by which the MMCO can carry out his production responsibilities. Resources provided by the type wing which affect the squadron maintenance production include; coordination for technical support from depot activities, coordination of short and long term maintenance requirements such as depot inductions, management support for associated management information systems, and monitoring technical data accuracy for items such as technical directives (CNO, 1995, Vol. I, para. 5.2.2.1). When deployed, it is the carrier air wing maintenance officer who is tasked with coordinating maintenance support requirements for the squadron. Whether ashore or afloat, the associated maintenance officer plays a significant role in squadron maintenance productivity. Communication and effective exchange of information is critical to the smooth coordination of maintenance support requirements.

The MMCO is in daily communication with the air station or ship supply department. Requisition status, tracking of repairable components, inventory range and depth, and order cycle times all play a part of influencing maintenance decisions. Similarly, communication with the air station or ship aircraft intermediate maintenance department occurs frequently as the MMCO coordinates technical service, testing or calibration service support. Again, effective exchange of information amongst these various organizations enhances the maintenance effort.

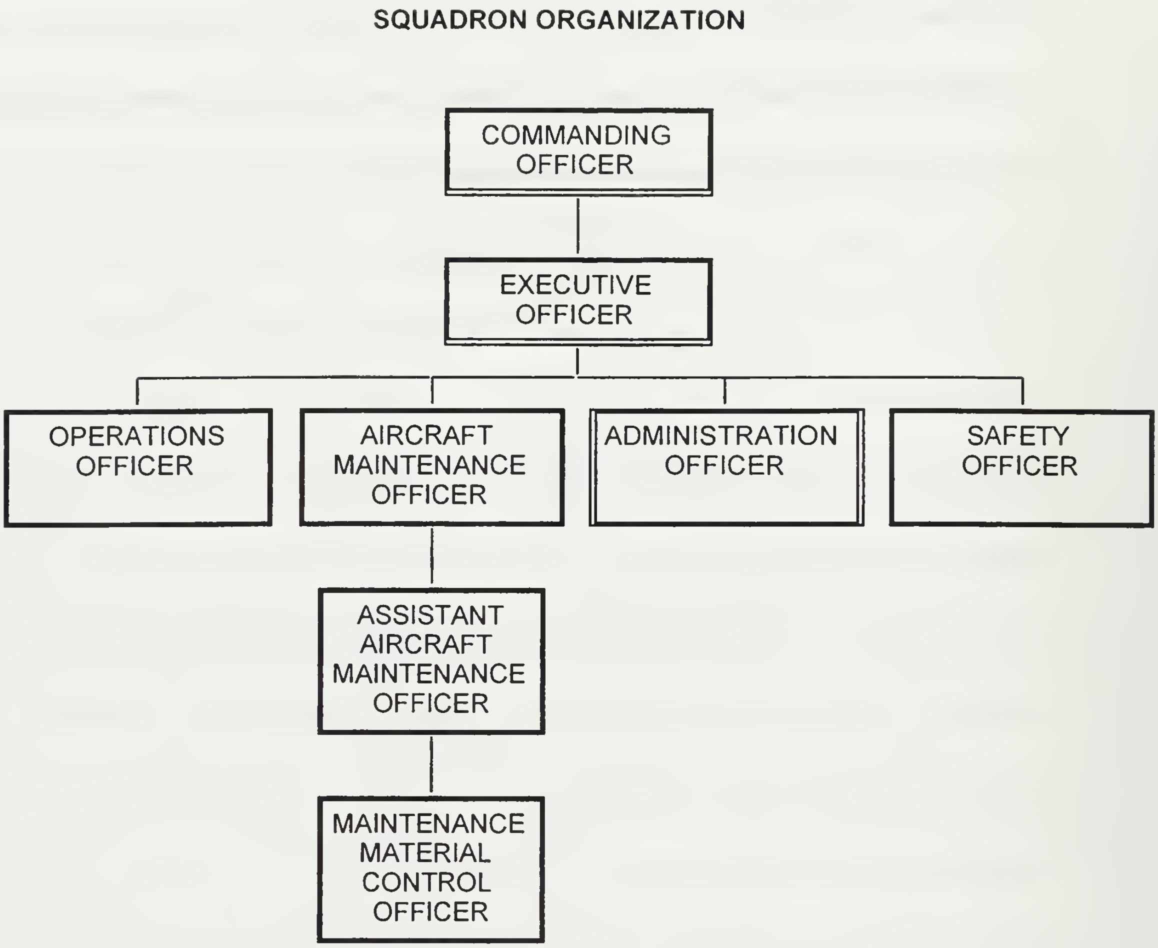

Figure 2.1 Typical Aviation Squadron Organization

The MMCO relies upon the talents of the maintenance control staff to accomplish the numerous maintenance control functions. The MMCO is supported by experienced Chief Petty Officers and a Maintenance Master Chief Petty Officer to carry out production control functions. A logs and records staff is provided to maintain aircraft records and to carry out clerical functions in support of maintenance control activities. Also, storekeepers and a Material Control Officer assist the MMCO in requisition tracking and material support. The size of the total maintenance control staff varies with the type and size of squadron.

C. DECISION TIME FRAMES

The various production decisions made by the maintenance material control officer are affected by the context of the time frame in which they are conducted. Three production decision time frames will be discussed in this analysis, short-term, intermediate, and long-term. Each of these time horizons are influenced by a different set of demand requirements. Inevitably, decisions made in the short-term will eventually have long-term consequences. The length of each time frame varies according to the perspective taken when discussing the given period. This discussion will be in the context of a planning horizon táken from the squadron MMCO's perspective.

The time frame for short term maintenance decisions spans from one to 30 days. The primary demand requirement in this period is the daily flight schedule as promulgated by the squadron operations department. The daily flight schedule is typically not known until the preceding evening. Production decisions made in this context focus on maximizing aircraft availability while minimizing aircraft downtime. Maintenance scheduling is primarily a reaction to unscheduled maintenance demands which become known as aircraft return from their current assigned sorties. Unscheduled maintenance actions are unpredictable, and arise as a result of a failure to a component or system. A secondary demand requirement which must be met in the short-term are the scheduled maintenance actions. Scheduled maintenance actions are calendar and special inspections which are scheduled in the monthly maintenance plan to meet preventive maintenance requirements. One objective is to maximize maintenance yield; the number of allowable hours or days flown, per the actual hours or days flown (Gray, 1992, p. 25). A second objective is to incorporate these scheduled maintenance actions into the daily production plan so as to not interfere with the daily flight schedule. Maintenance control at this point almost becomes an art form as a balance between maximizing maintenance yield with aircraft availability is sought.

Maintenance decisions which occur over an intermediate time frame span from 30 days to one year. These scheduling decisions are driven by major preventive maintenance commitments such as phase inspections. Aircraft modifications performed by depot field teams may also fall into this category. Aircraft mishaps may bring about depot field team repairs which also span the intermediate time frame. Special requirements in terms of facilities, specialized support equipment and technical assistance are constraints which must be taken into consideration.

Long term maintenance decisions span from one year and beyond. The depot induction schedule is the primary consideration for this time frame. Although the squadron does not conduct the depot rework, preparation for inducting the aircraft to the depot does require a significant number of maintenance hours at the organizational level which the MMCO must coordinate with other maintenance workloads. The type wing maintenance officer coordinates the depot induction schedule; and is reliant upon accurate maintenance and flight hour data from the squadron.

D. CRITICAL INFORMATION ELEMENTS

The responsibilities of the maintenance material control officer have previously been divided into five general functional areas; personnel, support, configuration management, reports/ administration and production management. Each of these functional areas is comprised of critical information elements which drive the MMCO's decision process in formulating maintenance management decisions. This section will discuss each of these elements.

A primary constraint in carrying out the maintenance effort is the availability of qualified personnel. The production control function is responsible for monitoring the workload of each maintenance workcenter, and assigning the priority of each maintenance task. The quantity and qualification of these personnel needs to be accessible to the MMCO and other production control personnel if assignment and monitoring of the maintenance department workload is to be done intelligently.

Maintenance decisions also rely on information regarding various elements of support provided outside the squadron. Funding from the wing for various budget elements of the squadron will have an impact on the quantity of flying available to the squadron. Maintenance hours per flight hour from historical archives can be used to determine the potential workload over a given period. Information regarding requisition status and parts availability invariably influences maintenance decisions and prioritization. Cannibalization of a down aircraft to fix another aircraft is the frequent result when the MMCO and production control personnel are uncertain about receiving a crucial part in time to ready an aircraft for the daily flight schedule. Similarly, the availability of intermediate level technical support and support equipment frequently plays a role in maintenance decisions within the organizational level.

Configuration management is made up of four information elements. The first are the serialized components and software installed on each aircraft. Second, usage data compiled to date on each aircraft. Next, the maintenance history of each aircraft which reflects the incorporated and unincorporated technical directives. Last, any maintenance deadlines concerning technical directives or life limited components are critical information elements which have a direct bearing on safety of flight.

The MMCO is responsible for processing a myriad of reports which reflect aircraft status, component tracking, engine tracking, status of outstanding technical directives, and so on. The organizational level is the primary data collection point of aviation maintenance data. The reports processed by the MMCO are formatted for use by higher levels to make fleet management decisions. The data elements for these reports is similar as that used for configuration management; flight hours, maintenance man- hours, major components and their associated serial numbers. Inaccurate, or unreported data will provide a false picture of readiness and utilization to higher management levels.

Production management decisions at the organizational level are driven by demand and resources. Demand is derived from operational requirements as promulgated in the daily flight schedule. Resources are the combination of personnel, material, equipment and facilities. These demand and resource data elements are needed on a real time basis to make informed production decisions which will maximize the aircraft utilization at the organizational level.

E. INFORMATION CRITERIA

A standard of judgment is needed when evaluating a given system. In this study, three criteria will be used to evaluate the information system used by aviation maintenance activities, NALCOMIS: speed, accuracy, and accessibility.

Each of the criteria present a way to describe the management information available to the maintenance material control officer and the production control staff. Speed is an effective leverage against limited resources prevalent in the military environment of today. In the course of daily flight operations, the production control team headed by the MMCO will make numerous time sensitive production decisions.

Increasing the speed by which information travels enhances communication. This enhanced communication improves the quality of the decisions to be made.

Accuracy of information also affects the quality of a decision. Information received in a timely manner is useless if it is not representative of actual conditions on which the decision is to be based upon. A timely decision serves no purpose if it is not credible. Information which has no credibility eventually becomes neglected because it is of no benefit to the user. Unused, inaccurate data elements occupy valuable storage space and slows the decision making process. Conversely, reliable, accurate information adds value to the production process.

Timely, accurate information is worthless if the user cannot access the information when it is required. The dynamic production environment of the organizational level necessitates that maintenance management information be provided on a real time basis whenever possible. Portable, PC based systems are the means by which the MMCO will have the most flexible access to timely maintenance management information. The MMCO requires access to information fields which will provide timely, accurate information for short term and long term decisions.

F. SUMMARY

The daily production decisions made by the MMCO have short and long term impacts upon the overall life cycle costs of the aircraft in their cognizance. These production decisions involve varying functional areas which include personnel, support, reports processing, configuration management and production scheduling. The MMCO's decisions are not made in isolation, they are reliant upon personnel and support availability. The coordination of these resources must also be integrated to meet the commitments set forth by the operations department. An information system which can provide timely, accurate, accessible information will add value to the MMCO's decision making capability.

III. OVERVIEW OF NALCOMIS

A. INTRODUCTION

The Naval Aviation Logistics Command Management Information System (NALCOMIS) concept originated in the mid 1970's. Reductions in manpower and funding were prevalent in the defense environment during this period. Additionally, the increasing complexity of aircraft systems and rising operations tempo for Naval aviation squadrons required greater efficiencies in the use of maintenance resources. The manual Aviation Maintenance and Material Management System (AV-3M) in place at this time was slow and labor intensive. NALCOMIS was intended as a management information system which would address the shortcomings of the manual system which consisted of ; "a lack of real-time management information, a difficult data collection process, and inadequate and inaccurate upline information" (McCaffrey, 1985, pp. 85- 87).

The initial development for NALCOMIS was approved in 1977, and full scale development began in 1979. The initial prototype was delivered for testing to MCAS Cherry Point, NC in 1983. The NALCOMIS software was developed in two modules: OMA (organizational maintenance activity) and IMA (intermediate maintenance activity). The testing and certification of the OMA module lagged behind that of the IMA module (McCaffrey, 1985, p. 87). By 1992 implementation of NALCOMIS OMA throughout the fleet had begun.

B. CURRENT CAPABILITY

The Naval Aviation Maintenance Policy emphasizes the importance of the maintenance manager to effectively monitor and control various maintenance elements which fall into that manager's responsibility. In this context a maintenance manager ranges from the workcenter supervisor to the maintenance department head.

> It is the responsibility of all maintenance managers to manage their resources in an efficient manner. To accomplish this task they must maintain control of the various elements within their area of responsibility. Effective control is dependent upon the availability of current status information on these elements. NALCOMIS provides this information (CNO, 1995 Vol. III, para. 5.2.1.2).

NALCOMIS is the intended management tool through all levels of the squadron maintenance organization to control the production effort by providing real-time information. Each maintenance workcenter within the squadron is connected to a host computer via a local area network (LAN). Maintenance administrative data such as work center, aircraft bureau number, job control number, supply status, job status, manhours expended and type of maintenance are all entered into NALCOMIS. Various reports, such as workload status reports can be generated from the data kept in NALCOMIS. The reports available from NALCOMIS do not have any graphics, nor do they allow any type of heuristic "what if " analysis for production scheduling and decision making. The data entry for NALCOMIS is manual; so the effectiveness of the system is dependent upon timely and accurate data entry from maintenance technicians, maintenance control personnel and logs and records personnel.

Each squadron uses the OMA module of NALCOMIS. The AIMD and Supply Support Center (SSC) use the NALCOMIS IMA module. There is a limited amount of inter-communication between the OMA and IMA modules. The organizational level benefits the most from the limited amount of information sharing available between the two modules. A squadron can access material management type of information such as parts availability from the SSC or repair status information from the AIMD. One limitation to the current NALCOMIS network is that activities are only connected within the local area. Additionally, data entry is not seamless between the three types of activities. Redundant data entry is sometimes required as information of a particular aircraft component travels between maintenance levels and the SSC.

C. DATABASE RELATIONSHIPS

NALCOMIS is just one source of aviation logistics data. Various databases, each with a different intended function, form a powerful base for future information system applications. This section will discuss the relationship between three database systems which function within the aviation maintenance data system network: NALCOMIS, NALDA, and ECAMS.

1. Naval Aviation Logistics Command Management Information System (NALCOMIS)

NALCOMIS, may be described as a transaction database. All maintenance actions at the OMA are recorded through NALCOMIS. Each maintenance action is entered into NALCOMIS by filling in the appropriate data fields of a computerized VIDS/MAF (Visual Information Display System/ Maintenance Action Form). The VIDS/MAF was the paper form used in the manual AV-3M system. Each squadron stores the current month and two previous months VIDS/MAFs on their host computer (CNO, 1995, Vol. III, para. 5.2.6.). The off loaded data are sent upline to a data services facility (DSF). The DSF processes all the NALCOMIS data from a ship or air station. These data are then sent to the NALDA database.

2. Naval Aviation Logistics Data Analysis (NALDA)

NALDA is the main data repository for aviation maintenance data throughout the Navy. It has numerous data sources, approximately 25 databases, of which AV-3M data from NALCOMIS is the major source. Other sources of data come from Naval Aviation Depots and the Aviation Supply Office.

NALDA had it origins in the mid 1970's when a need arose for the Navy to develop a system which would consolidate the various aviation logistics databases which were coming into existence. The original NALDA development plan was approved in 1976. The development plan encompasses four phases, of which Phase II is currently underway. NALDA Phase I enabled research and development analysis to be conducted on a wide range of logistics support applications. The original targeted users did not include the OMA level. However, there has been an increase in accessibility to NALDA from the organizational level via the internet. Enhancements are currently in work to make the data bank more user friendly. The reports and data now available on NALDA are useful in analyzing historical trends, but is not a decision tool for daily maintenance management decisions at the OMA. An obstacle in using NALDA at the organizational level is that the most recent data are 60 to 90 days old. Recently completed database mergers within NALDA should reduce this age for the newest data to 20 to 30 days (Christensen and Pasadilla, 1991, pp. 46-47). Other obstacles for greater use of NALDA at the OMA are the problems of incomplete data capture and inaccurate data. Problems with NALDA from the MMCO perspective will be discussed more fully in the next chapter.

3. Enhanced Comprehensive Asset Management System (ECAMS)

The F/A-18 Hornet program incorporated the use of ECAMS. ECAMS is a computerized monitoring system for the F404 powerplant and selected avionics and airframe components of the F/A-18. Flight data and component failures of the aircraft are captured on a removable cartridge located in the cockpit. This cartridge is referred to as a Data Storage Unit (DSU). When space on the DSU is almost full, a three digit code appears on the Maintenance Monitoring Panel (MMP) of the aircraft, which alerts the maintenance technician to remove the DSU and have its data downloaded into an ECAMS Processing Unit . This processing is accomplished by squadron logs and records personnel who download and store the data into the ECAMS system. The "stripped" DSU is then reloaded into the aircraft.

Flight data downloaded into ECAMS is used to process various reports which calculate airframe and engine life cycle usage, as well as fault analysis for avionics components. ECAMS data flows upline from the OMA to the IMA for further processing. From the IMA the data is sent via the contractor to the Parts Life Tracking System database which uses the NALDA interface computer. A telecommunications network is used to transport the data (Christensen and Pasadilla, 1991, pp. 38-39).

The advantage in a data collection system such as ECAMS is its automation. The only manual processes are the removal and replacement of the DSUs. There is a variety of reports which may be processed for trend analysis at the organizational level. ECAMS has brought a higher degree of precision in monitoring the fatigue, or aging, of an aircraft and its systems. The effectiveness of ECAMS data is reflected in its incorporation into other aviation programs.

IV. MMCO INFORMATION REQUIREMENTS AND NALCOMIS PERFORMANCE

A. INTRODUCTION

The ultimate evaluation of a given information system rests on how well that system performs in meeting the user's requirements. The dynamic work environment of the MMCO makes timely decisions valuable to the maintenance effort in its contribution to operational readiness. An effective information system in this environment needs to provide timely information which contributes to the effective day-to-day maintenance management of the squadron's aircraft. "User friendly" systems which present information in a usable format enable the user to quickly process the information needed to make a decision. Chapter II introduced five functional areas of the MMCO decision making process: personnel, support, configuration management, reports processing and production management. This chapter will evaluate the value of information provided in these areas by NALCOMIS.

B. METHODOLOGY

There have been no formally documented studies which have measured the value and usefulness of information provided to the MMCO by NALCOMIS. Quantifiable measurements in this area would be difficult to ascertain. Personnel holding the MMCO billet have various educational backgrounds as well as varying areas of personal expertise. The way in which any given MMCO approaches a decision and the information used to make a decision will vary. However, the functions which each MMCO must perform will remain the same. The type of information necessary to aid in decisions within these functions should also remain the same.

The methodology used to evaluate NALCOMIS will consist of taking each of the five MMCO functional areas and dividing it into sub-elements. These sub-elements are pieces of information necessary which are necessary to make an informed decision for a specific functional area. The evaluation of NALCOMIS in each of these sub-elements will consist of four questions:

1. What is the impact on the decision to be made?

2. Is there an available NALCOMIS application?

3. If there is a NALCOMIS application available, what is its usefulness in terms of speed, accuracy and accessibility?

4. If there are no NALCOMIS applications available, what are the ramifications?

The intent of this methodology is to establish a baseline of how much decision information required by the MMCO is provided by NALCOMIS. Chapter III explained that NALCOMIS is not the only automated database available to the MMCO. ECAMS and NALDA are also potential sources of decision information. It is not within the scope of this thesis to evaluate the ECAMS and NALDA systems. However, these systems will be included when there is an application which specifically contributes to the quality of the MMCO decision making process.

C. EVALUATION OF THE MMCO FUNCTIONAL AREAS

1. Personnel Management

a. Availability

Coordination of the daily workload and production priorities of the maintenance department begins with knowing the production capability from a personnel standpoint. This production capability may vary slightly each day as the availability of maintenance technicians change. Variable conditions in maintenance personnel management arise from military duties, operational commitments and personal requirements of the maintenance personnel.

Aviation maintenance personnel in the Navy have a wider range of professional commitments than their civilian counterparts. Navy personnel are obliged to perform military duties in addition to their daily professional tasks as maintenance personnel. These military duties may be in the form of watch requirements for the duty section of that day. Training obligations for programs outside the scope of aviation maintenance are another form of military duty. In many cases, the performance of military duties will take precedence over performing the daily tasks of aircraft maintenance. Other distractions from the maintenance effort occur when preparations for inspections or ceremonies must be made, or workcenter spaces must be cleaned. All of these military duties will, in some combination, have an impact on the personnel availability for any given day.

Squadron operational commitments, such as detachments, also have an impact on the availability of maintenance personnel. Detachments occur when aircraft and personnel are geographically separated from the squadron. Training detachments are used to enhance aircrew proficiency in certain combat elements. Operational detachments occur when a squadron is tasked to commit a part of its aircraft and aircrews for participation in a military exercise. In each case, the personnel availability to the production effort is impacted when technicians must be assigned to support a detachment.

Additionally, ensuring that maintenance personnel are motivated to perform their jobs requires that their personal needs be met. Circumstances such as illness or family emergencies will make people unavailable for work. All Navy personnel are given 30 days of leave each year in an effort to prevent them from "burning out". Meeting the personal needs of those who make up the maintenance department will affect the capability of the production effort each day.

The multiple conditions which affect the availability of maintenance personnel ensures the production capability of the maintenance department will change daily. The MMCO and the production control staff require a system which communicates the capability of the department from a personnel standpoint. If this information is not available to production control, then inefficient workload assignments may result as workcenters are over burdened. Quantity of personnel do not solely reflect the maintenance capability from a personnel standpoint, however. The qualifications of the maintenance personnel is a critical piece of information as well.

b. Qualifications

A rating in the Navy for enlisted personnel calls for specific skills and aptitudes. An aviation maintenance technician in the Navy qualifies for a rating by completing training received from a "Class A" school; or by receiving on the job training and successfully achieving a rating via a semi-annual rating exam. There are eight aviation technical ratings at the organizational level of maintenance, covering areas in; airframes, avionics, ordnance, powerplants, survival equipment and environmental systems. Navy Enlisted Classification (NEC) codes provide more specific management information regarding areas of special training or expertise within a given rating. Generally, a maintenance workcenter is comprised of personnel with the same rating.

The complexity of modern aircraft systems and the inherent dangers associated with the aviation environment necessitates that a certain level of expertise be achieved to carry out a given maintenance action. Every maintenance action on an aircraft must be inspected-twice. The first level of inspection is performed by a workcenter technician, known as the Collateral Duty Inspector (CDI). A technician must demonstrate a thorough knowledge of a given aircraft system, and attain a certain level of experience before being recommended as a CDI. A CDI qualification must be authorized by the Aircraft Maintenance Officer. A second level of inspection is performed by a

Quality Assurance Representative (QAR). Quality assurance is a separate division which reports directly to the Aircraft Maintenance Officer. Qualification as a QAR is more rigorous than that of the CDI, and is held by more senior enlisted rates, usually a First Class Petty Officer.

The support equipment required to maintain aircraft systems can also be complex and expensive. For this reason, and to ensure the equipment is operated safely, support equipment licenses are required to operate these pieces of equipment. Qualification for these licenses requires classroom instruction and on the job training. Additionally, Explosive Ordnance Handling certification is required for personnel who handle cartridge activated devices, pyrotechnics or aircrew escape propulsion systems. Gas Free Engineering qualification is necessary to accomplish removal of aircraft fuel cells.

The successful completion of a maintenance action on an aircraft requires more than having a sufficient number of technicians. These technicians must also have a certain level and type of qualification before this action can be carried out. Qualified technicians to operate required support equipment must also be available. Coordination of the maintenance department daily workload must take into consideration the qualifications required to complete the given maintenance tasks. Usually this function is left to the workcenter supervisor. Conflicting priorities can be avoided if the MMCO and production control staff have a usable means of access to this information.

c. *NALCOMIS Evaluation*

Maintenance Control must have accurate information regarding the maintenance capability of its technicians for any given day. Monitoring the maintenance department workload cannot be effectively accomplished if the quantity and qualifications of the technicians available is not known. The MMCO also requires this information when deciding on personnel requirements for detachments. The lack of personnel management information at the MMCO level will result in unrealistic production planning which will result in bottlenecks, delaying the accomplishment of aircraft maintenance. Delays in the production plan will upset the operational plan. The end result is missed sorties which may impact air wing operational requirements.

In terms of personnel management, NALCOMIS provides the capability to monitor the current assigned workload of the maintenance department. This workload status is broken down into the workcenter level. Basically, the MMCO and maintenance control personnel can know which maintenance tasks are in work, completed, awaiting maintenance, or awaiting replacement parts from supply. The speed of this information is provided real-time. The accuracy of this information, however, is dependent upon the workcenter supervisor entering the proper data into NALCOMIS. A maintenance task completed two hours ago may still indicate being “in work”, if the workcenter supervisor is not caught up with the administrative duties of entering data into the information system. The information in NALCOMIS is easily accessible since virtually every workcenter has a NALCOMIS terminal.

The information provided by NALCOMIS does not provide maintenance capability from a personnel standpoint. The MMCO and maintenance control are reliant upon inputs from the workcenter or division to know what may be realistically assigned in terms of workload. Vulnerabilities in communicating this type of information verbally, or in the form of a muster report leave a wide avenue open for unrealistic workload assignments. The lack of accurate, real-time personnel management information exposes the risk associated with misuse of personnel resources. This risk can manifest itself in an unrealistic production plan which may impact the operational readiness of the squadron.

2. Support

Maintenance support received by the organizational maintenance activity is received from two primary sources; the Supply Department and the Aircraft Intermediate Maintenance Department. The Type Wing and Air Wing provide indirect maintenance support such as scheduling depot level field teams; but for this discussion of NALCOMIS, discussion of the Wing activities is not necessary.

a. Supply

The tempo of operations at the squadron level make for a dynamic decision making environment. Maintenance decisions required in response to a change in an aircraft's status during the course of daily operations must usually be made quickly. The determination of these maintenance decisions will hinge on the availability of a component required to return an aircraft to an "up" status. Information in this context is time sensitive. The inability to provide a repair part within a time constraint may result in cannibalization, where a good component needed to fulfill the maintenance action is removed from another aircraft already in a down status. Cannibalization results in redundant maintenance actions, and expose components to damage as they are removed and replaced in other aircraft. Fast, accurate supply information can help alleviate cannibalization.

b. AIMD

The primary function of AIMD is to repair aircraft components and return them to Supply. Occasionally there are no spare components available. When demand for such a component becomes evident, an "EXREP" (expeditious repair) is called for from AIMD. In these circumstances, the repair status of the EXREP component will have an impact on maintenance decisions being made at the squadron. Again, cannibalizations may be dependent upon the time in which the required component can be provided.

Technical assistance is another support function provided by AIMD for organizational maintenance activities. On-aircraft intermediate maintenance level actions such as Non Destructive Inspections (NDI), or on aircraft repair of large structures are two examples of AIMD technical assistance. Coordination of this maintenance usually involves a level of planning which precludes the requirement for time sensitive decisions. Information regarding AIMD repair capability is useful to the squadron MMCO in the coordination of maintenance actions which require technical assistance.

c. *NALCOMIS Evaluation*

Support information regarding repair parts availability will influence the production control plan. Cannibalization may be deemed necessary if the information on repair parts status is negative, unavailable, slow in receipt, or suspected of not being accurate. Any time a cannibalization is initiated, the efficiency of the maintenance effort is degraded.

NALCOMIS provides query capability between the OMA, IMA and Supply activities. This enables squadron production personnel to ascertain information regarding the availability of a needed aircraft component to repair an aircraft. This information can be provided in real time. Accuracy of the information is susceptible to human error since data are entered manually. Also, the timeliness of the information depends on when Supply or AIMD personnel update their NALCOMIS records.

3. Configuration Management

Configuration management controls changes to the physical characteristics of a system, records these changes and their implementation status (Blanchard, 1996, p. 403). The configuration management program was established to achieve required aircraft performance, operational efficiency, logistics support and readiness (CNO, 1995, Vol. I, para. 10.22.1). Components which make up the numerous systems within an aircraft can be identified by nomenclature and serial number. Maintaining an accurate accounting of the configuration of a complex weapon system such as an aircraft is a daunting task. Knowing the particular configuration of each aircraft is a prerequisite for efficiently maintaining this weapons system throughout its lifecycle.

Implementation of approved configuration modifications is accomplished through the Technical Directive (TD) system. TDs are monitored by the Technical Directive Status Accounting Program (TDSA) (CNO, 1995, Vol. I, para. 10.22.1) Technical directives are modifications or one time inspections to an aircraft or engine. Modifications may or may not involve components tracked by serial number. These directives may involve changes to the aircraft's structure and do not occur on a removable component. The MMCO is concerned with three elements of configuration management; component identification, requisition tracking and technical directive incorporation.

a. Component Identification

The components which make up the systems in an aircraft are affected over time by age, technical innovation or modifications required to improve performance or safety. Component tracking maintains visibility of specified aircraft components by their nomenclature, part number and serial number. This data allows the MMCO to have detailed information about a particular aircraft. Life-limited components such as engines, tailhooks or landing gear struts must be monitored continuously to ensure engineering tolerances are not exceeded.

Other components on an aircraft may be software driven, such as mission computers. These computers are essentially the "brain" of the aircraft. Advances in software performance necessitate that software loads be updated on aircraft components which are software driven. Component tracking through configuration management monitors the incorporation of software updates. Aircraft components may be modified physically as well. Such modifications may be for reasons of performance or safety. In either case, the MMCO and squadron maintenance personnel must be able to know which modifications are incorporated within an aircraft.

b. Requisition Tracking

When a technical directive is issued against an aircraft, various parts may be required to incorporate that directive. The directive will usually specify a parts kit which is required for incorporation. These parts kits are not always readily available from Supply, so tracking of these requisitions becomes a part of monitoring the implementation status of the directive.

c. TD Incorporation

Time constraints may be placed upon the incorporation of a technical directive, also. Technical directives classified as "urgent" usually involve items which affect safety of flight. It is imperative that an MMCO have visibility of this information in order to avoid jeopardizing the safety of squadron personnel. Other technical directives are intended to be incorporated during scheduled maintenance activities such as phase inspections. In this instance the MMCO must ensure applicable parts kits and any technical assistance from AIMD are available when the phase inspection is scheduled.

d. NALCOMIS EVALUATION

Successful configuration management of an aircraft or engine will obtain the Navy's objectives or performance, lifecycle cost and reliability for that asset. Configuration management which is carried out inefficiently will fall short of the desired performance, cost, reliability objectives; and may become a burden rather than an asset. Changes to the configuration of an aircraft are usually done at the OMA. The MMCO and the production control staff will make the management decisions which will ultimately determine how efficiently an aircraft was maintained in terms of configuration management. An information system which can add value to these decisions will help to attain the lifecycle performance, cost and reliability objectives. The production management team headed by the MMCO needs information which enables timely component identification, accurate monitoring of life-limited components, and will allow for the efficient incorporation of technical directives in terms of maintenance, material and facility coordination.

NALCOMIS provides an application for the tracking of TD incorporation and parts kits. Within NALCOMIS is the Logs and Records Subsystem which maintains configuration of each aircraft, engines and components assigned to that squadron. NALCOMIS has a capability which allows the user to create reports from MAF data entered manually into the system (CNO, 1995, Vol. III, para. 7.4). The reports are of a row and column format with no graphics or visual cues about TDs requiring urgent incorporation. Activities which have ECAMS capability can track life-limited components based on automated data from the aircraft DSU. The user can create various reports to track these components. These reports are in a similar format to NALCOMIS, without a graphics capability.

The reports provided by NALCOMIS and ECAMS are valuable to the configuration management effort. The weakness in the data provided by NALCOMIS is that it is manually obtained and entered into the system. Component identification relies upon serial numbers written down by a maintenance technician, then entered into the system. The information is readily accessible once the format of the reports is selected. Timeliness and accuracy of the information is reliant upon the most recent data input by the maintenance technician or logs and records clerk. ECAMS data is available as soon as the DSU is downloaded from the aircraft. Since it is automated, the data is not vulnerable to mistakes associated with manual entry. ECAMS is not as accessible as NALCOMIS since it is contained in a separate computer system which has fewer workstations within the squadron.

4. Reports Processing

The function of reports processing is different from the other MMCO functions discussed in that it presents itself as more of a task than as a management issue.

Nevertheless, the MMCO will spend the majority of available management time in screening, verifying, correcting and tracking of these various reports. Since the reports are submitted for the benefit of higher managerial activities, accuracy and timeliness is important. An information system can add value to this process by providing accurate information for higher-level decision making, and by reducing the time spent in the administration of these reports by the MMCO. It is not the intent of this thesis to discuss every report for which the MMCO is accountable. Discussion of three common categories of reports will provide a backdrop in which NALCOMIS may be evaluated.

a. NAMDRP Reports

The cost of Navy aircraft and the value of the personnel who fly and maintain them, demand a system which will quickly broadcast potentially hazardous situations throughout the fleet. The Naval Aviation Discrepancy Reporting Program (NAMDRP) provides a means by which hazardous conditions, faulty procedures, erroneous technical publications or materials of insufficient workmanship can be reported (CNO, 1995 Vol. I, para. 10.6). There are five types of NAMDRP reports; Hazardous Material Reports (HMR), Quality Deficiency Report (QDR), Engineering Investigations (EI), Technical Publication Deficiency Report (TPDR), and Aircraft Deficiency Report (ADR). In cases where there is a potential for death or injury to personnel, or loss or damage to equipment; the report must be submitted within 24 hours. The NAMDRP program is a valuable tool in providing improvements to Naval aviation through discovery and reporting of hazardous and sub-standard conditions.

b. XRAY Reports

OPNAV XRAY reports provide aircraft accounting status. These reports give the reportable condition of the aircraft; such as if it is in preservation status or reportable condition. These reports provide a fleet-wide picture of the overall condition of Naval aircraft. The readiness information provided by the reports necessitates that they be submitted timely and with complete information.

c. Engine Transaction Reports

Engine Transaction Reports (ETR) give accounting status of aircraft engines and their modules. An ETR is submitted each time an engine is transferred to another activity. These reports provide the location of all aircraft engines and their readiness condition. Similar to XRAY reports, ETRs provide a fleet-wide condition of aircraft engine location and status.

d. NALCOMIS Evaluation

NALCOMIS contains all the data required to produce these administrative reports previously discussed. However, there is no application which can produce the reports automatically. This results in lost time on the behalf of logs and records personnel, the Maintenance Master Chief Petty Officer and the MMCO, as redundant reports must be prepared and screened. Since the reports are manually entered into a data base at the receiving activity, turnaround times for responses is slowed. Additionally, a tracking system must be provided by the submitting activity. Filing and tracking these reports results in more time spent on administrative functions, rather than maintenance management analysis.

5. Production Scheduling

Production scheduling is the function which is the heart of what the MMCO and the production control staff do on a daily basis. The production schedule is the plan by which squadron aircraft are maintained in, or returned to mission capable status. The dynamic operational environment of Navy squadrons requires the production schedule be formulated on a daily basis, with new iterations throughout the day. The production scheduling decision function can be categorized into five sub-elements: daily operational commitments, unscheduled maintenance requirements, scheduled maintenance requirements, aircraft modification requirements, and production constraints. The production schedule is the synthesis of these five sub-elements, which over time will accomplish short term, intermediate and long term maintenance requirements.

a. Operational Commitments

The operational commitments for each day are contained in the daily flight schedule for the squadron. The flight schedule includes information which annotates the briefing, launch, recovery time of each event (sortie), the type of mission the aircraft is to fly , numbers of aircraft required for each event, and the aircrew assigned to that event. Maintenance control will assign the specific aircraft to an event, and relay this information to the squadron duty officer (SDO). Aircrew receive their aircraft assignments from the SDO. The important information contained in the flight schedule from the MMCO perspective are the types of sorties to be flown and quantity of aircraft required to fly those sorties. The flight schedule is usually written one day prior to the next day of operations. Maintenance control will usually receive tomorrow's flight schedule in the afternoon or evening, leaving a relatively short production planning time frame.

b. Unscheduled Maintenance Requirements

R. T. Allen pointed out that;

> ...maintenance on naval aircraft most often takes place as a result of the unexpected failure of some component or subsystem in the aircraft. Such failures make the management of naval aircraft maintenance difficult and filled with uncertainty. (Allen, 1988, p. 50)

Production planning for unscheduled maintenance requirements takes place on a short term basis. Management information at this level is time sensitive because any differences between flight schedule requirements and available aircraft must be filled by the timely accomplishment of unscheduled maintenance. Unscheduled maintenance requirements are the primary driving force behind the prioritization given to maintenance tasks. Short term requirements, however, must be balanced with longer range production plans.

c. *Scheduled Maintenance Requirements*

Scheduled maintenance requirements are necessary to sustain readiness levels achieved through the execution of a preventive maintenance plan. Formulation of the preventive maintenance plan begins in the early stages of an aircraft program. The duration of an aircraft's lifecycle and the costs accumulated over that lifecycle are directly affected by the degree to which the preventive maintenance plan is followed by the OMA. The reliability of an aircraft is dependent upon the accomplishment of the preventive maintenance plan. Preventive maintenance consists of routine servicing and inspections intended to prevent failure (Heizer and Render, 1996, p. 826).

Scheduled maintenance activities are calendar based, condition based or flight hour (usage) based. Intermediate range planning is appropriate for the majority of these activities. Information at this level is not as time sensitive relative to unscheduled maintenance requirements. Most scheduled maintenance requirements can be projected in the 30 day monthly maintenance plan due from the MMCO on the 25th of each month (CNO, 1995, Vol. I, para. 11.6.2.1.3).

d. *Aircraft Modification Requirements*

The operating service life of an aircraft can be enhanced and extended through periodic inductions into Depot level modifications or overhauls. Modifications may be accomplished at the squadron's home air station by a depot field team, or at the depot facility. Extensive aircraft rework is done primarily at the depot facility. In each case, coordination is accomplished by the Type Wing Maintenance Officer. Due to the level of coordination necessary to perform this level of maintenance, planning occurs over a long term time frame. The OMA does not carry out this level of maintenance, but must spend numerous maintenance hours in preparing the aircraft for induction. When the aircraft is returned to the OMA, numerous maintenance hours are often spent ensuring the aircraft is back to full mission capability. These maintenance tasks must be integrated into the production schedule with the unscheduled and scheduled maintenance workload.

e. Production Constraints

The maintenance requirements for a squadron must be performed under certain constraints. A production schedule is meaningless without careful consideration of these constraints (see paragraph IV.C.5). The availability of repair parts and materials, qualified personnel, appropriate hangar facilities, and appropriate support equipment must be accounted for in the production schedule. Very often, the MMCO must have a contingency plan in case a constraint cannot be met.

f. NALCOMIS Evaluation

Production scheduling has the most significant impact on squadron performance of all the MMCO decision functions. The efficiency with which aircraft are maintained has a direct impact on squadron readiness. Readiness in terms of aircraft availability will determine the degree in which squadron operational commitments are met. The cumulative effect of daily production decisions affects the lifecycle cost of the aircraft as well as the aircraft service life.

The NALCOMIS subsystems contain the majority of the data necessary for effective production scheduling and report formulation; however, there is no specific production scheduling application. An example of such an application is a decision support system used in the commercial airline industry. American Airlines uses "Dockplan" which can formulate a five year maintenance plan for its fleet of 250 MD-80 aircraft in about eight minutes (Gray, 1992, pp. 28-29). The application uses a hybrid modeling approach in which the maintenance planner enters in constraints and repeatedly runs the model until a desired plan is reached. Previous research has recommended a similar application be implemented into NALCOMIS (Barnes and Harding, 1995, p. 68). The NALCOMIS reports which can be formulated to assist in intermediate or long term production scheduling are subject to the vulnerabilities of manual data entry discussed previously in this chapter.

The ramification of not having a direct production scheduling application for use by the MMCO is a sub-optimization of the maintenance resources and potential aircraft readiness. Production decisions are primarily based upon the combined human resources available in maintenance control. Although the personnel who fill these positions are extremely talented and bring a wealth of experience to the production scheduling process, their decisions will usually not be optimal. Research has shown that people do not always use all relevant information when making decisions; and that poor decisions are usually made in risky situations (Yates, 1992, pp. 28-29). In the maintenance control environment, production decisions are accompanied by an ocean of information, too much for any one person to effectively analyze in a timely manner. Given the time constraints, uncertainty of aircraft system failures, and associated pressures in meeting the flight schedule; it can be argued production scheduling qualifies for decision making under risk. The lack of providing the MMCO with timely production information in a usable format eventually results in higher aircraft lifecycle costs and degraded readiness.

D. FINDINGS

NALCOMIS benefits squadron maintenance managers by providing an electronic means to capture aircraft maintenance data. The MMCO and the production control staff have the capability to formulate a wide range of workload, configuration management, and repair status reports from the NALCOMIS database. The ability to query support status from Supply and AIMD activities is valuable to maintenance decision making at the squadron level. Overall, the introduction to NALCOMIS at the organizational level has improved the decision making capability of the maintenance managers.

Additionally, ECAMS is an effective supplement to NALCOMIS in monitoring life-limited assets. Unfortunately, ECAMS will no longer be functional after 31 December 1999. Without ECAMS capability, component life usage and structural fatigue life calculation accuracy will be severely curtailed; which will require additional spare components. The NALDA databank provides historical trend analysis information to the MMCO; but the data it contains suffers from loss in accuracy as it is passed upline. Also, the time lag associated with NALDA data hampers its use at the OMA as well. The benefits of NALCOMIS and the its supplemental systems fall short in fulfilling all the decision requirements of the MMCO and the production control staff.

The primary weakness of NALCOMIS is its reliance on manual data capture. Manual data entry is prone to human error and adds an administrative burden on clerks and technicians who must fill out electronic VIDS/MAFS. Timeliness and accuracy of data are vulnerable in this type of data capture system. An information system will only be useful if the data it is based upon is accurate. Manual data entry especially hinders configuration management due to the hundreds of TDs which must be tracked, and the susceptibility of lost component tracking through non-documented cannibalization actions.

Personnel management cannot be accurately assessed in terms of production capability within NALCOMIS. Personnel availability and qualifications are reliant upon documents such as the muster report and the monthly maintenance plan. The lack of this information in a real-time format leads to an increased risk in production bottlenecks. Since NALCOMIS does not have the capability to automatically process and track administrative reports such as NAMDRP, XRAY and ETRs, management resources are used in these administration activities rather than managing the production effort.

Finally, NALCOMIS does not provide a production scheduling application which can effectively assist the MMCO and production managers in making thorough decisions. Short, intermediate, and long term scheduling implications cannot be simultaneously evaluated to optimize maintenance resources and aircraft lifecycle costs.

NALCOMIS is not a true management information system. An information system contains information, not just numbers. It sends a message to the decision maker (Allen, 1988, p. 39). NALCOMIS does not fully realize the capabilities of available information technology to assist the MMCO in making effective maintenance management decisions of Navy aircraft. The next chapter will discuss future enhancements of NALCOMIS, and the development of an information system which can remedy the current shortfalls.

V. FUTURE INFORMATION TECHNOLOGY APPLICATIONS IN NAVAL AVIATION MAINTENANCE MANAGEMENT

A. INTRODUCTION

Efficient resource management of personnel, materials and equipment are prerequisites to maintaining the aircraft weapons system throughout its lifecycle within projected costs. Built-in-technology is one example of information technology improving the aviation maintenance process. Military aircraft such as the F/A-18 incorporate built-in-technology (BIT) to aid in the fault diagnosis for the aircraft. Aircraft are repaired faster due to rapid, more accurate troubleshooting. The reduction in turn around time (TAT) leads to an increase in readiness. There is a wide range of available information technology applications for use in aviation maintenance management which could yield further improvements in readiness, safety and cost reduction. Flight recorder technology embedded in modern aircraft is not currently used to its full potential from a maintenance management standpoint.

Introduction of NALCOMIS was an initial step in using information technology to aid maintenance managers such as the MMCO in decision making. Unfortunately, NALCOMIS is hampered by the inefficiencies of manual data entry. The previous chapter pointed out that the reports produced by NALCOMIS contain large amounts of data, but do not contain all of the information decision elements useful to the MMCO; which make it a questionable management information system. Automated data capture of flight information by ECAMS has proven an aid in monitoring life-limited components for those managers who have access to this system, and who know how to use it. But, software limitations will make ECAMS unavailable after 31 December 1999. The need for improved information technology applications for aviation maintenance management has been recognized, and enhancements to NALCOMIS are underway. This system, NALCOMIS OMA Release 4.1, will contain Configuration Management functions and include the use of a Windows NT infrastructure to support a Graphical User Interface (GUI). Additionally, NALCOMIS will be able to provide current ECAMS functions (NAVAIRSYSCOM, 1997, p. 2). However, these improvements to NALCOMIS do not fully address other information technology applications which will result in better aviation maintenance management decisions.

This chapter will discuss an initiative which will incorporate information technology to improve aviation maintenance management, the Automated Maintenance Environment (AME). A description of AME initiatives in the F/A-18 program will be given, followed by an OMA concept of operations, and a discussion of potential benefits and risks.

B. THE AUTOMATED MAINTENANCE ENVIRONMENT

The Automated Maintenance Environment is an initiative which recognizes the efficiencies to be gained in aviation maintenance processes through increased utilization of automated information technology. The AME initiative will remedy current weaknesses in aviation maintenance information processes through greater automation of these processes. Automating functions involving data entry, processing and extraction will reduce costs and improve data accuracy. Aircraft equipped with flight recorders, such as the F/A-18, are the weapons systems around which AME is being initially developed. Since the F/A-18 E/F is the pilot program to test AME concepts, the scope of this discussion will focus on processes involving this aircraft at the organizational level of maintenance. These concepts, however, involve technologies available to other programs such as the V-22 and the Joint Strike Fighter.

The rapid pace at which significant technological changes now occur, demand that information systems remain flexible in order to incorporate future changes which will benefit that system the most. The AME concept is based upon the use of aircraft specific application modules centered around an enhanced version of NALCOMIS OMA, Release 4.1 (NAVAIRSYSCOM, 1997, p. 2) known as Optimized NALCOMIS. The modularity of the AME system allows modifications to one module without the necessity of modifying the entire system. This modularity applies to the Intermediate and Depot levels of maintenance as well. The AME system currently under development for the F/A-18 consists of five application modules (NAVAIRSYSCOM, 1997, pp. 4-6). Figure 5.1 lists these modules and their general applications.

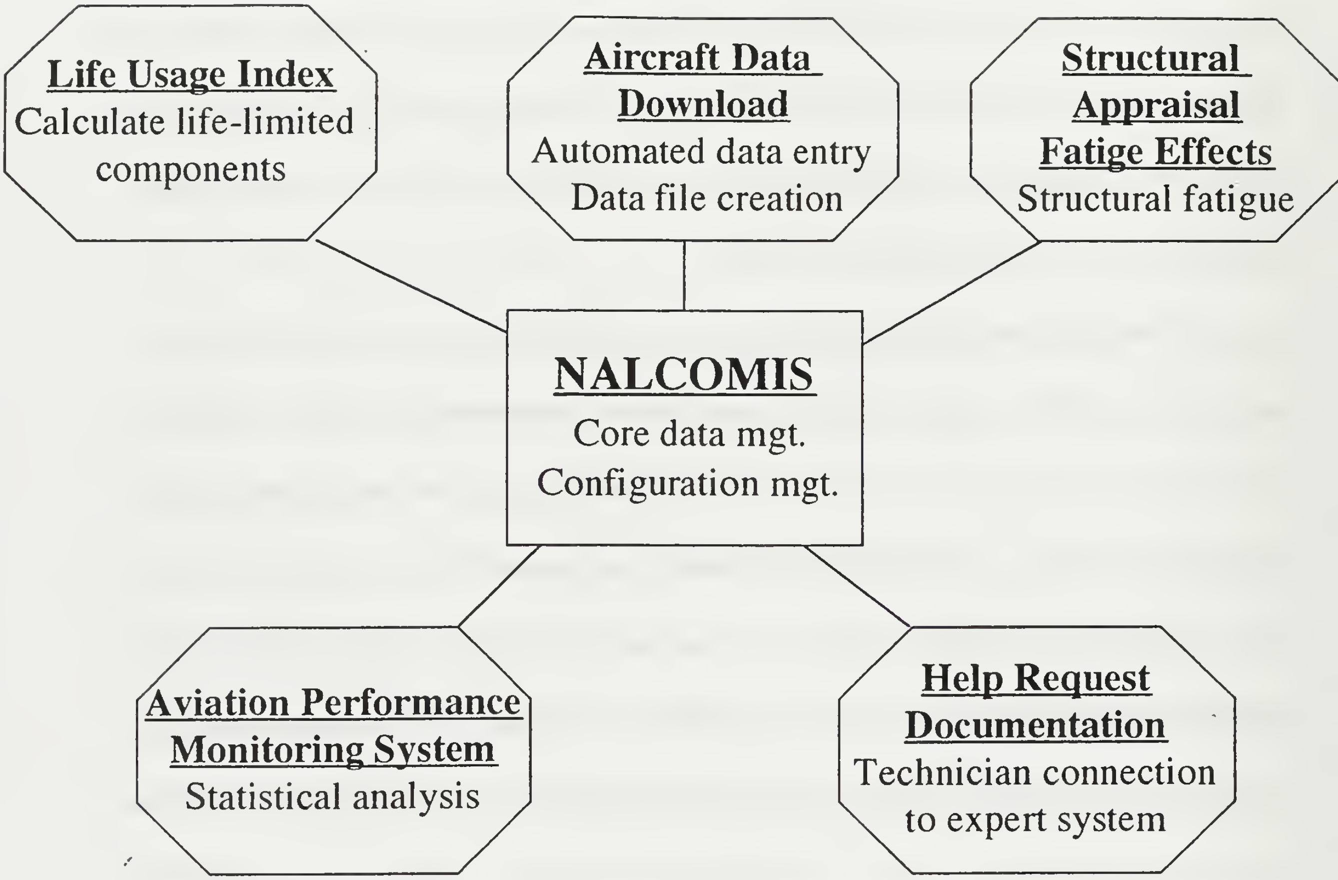

Figure 5.1 F/A-18 AME System

The features under development with the F/A-18 AME system enhance the capabilities of the maintenance technicians and the decision process of the maintenance managers. A brief description of each component of the system will be given, along with features that each application offers.

1. Optimized NALCOMIS OMA

Previously mentioned in this chapter, this version of NALCOMIS will be enhanced by the addition of ECAMS functions and Configuration Management (CM) functions. The incorporation of CM into NALCOMIS will enable activities to track specific components and their configuration changes as these components move between levels of maintenance. The tracking would include component history data, eliminating the need for paper documentation to accompany the component (NAVMASSO, 1997, p. 6).

2. Aircraft Data Download Module

The AME system relies on aircraft flight data captured on a removable Digital Storage Unit (DSU) which is downloaded after each flight and stored in a shared database. The aircraft data download module filters data stripped from the DSU, and creates an Aircraft Data File (ADF) for storage in the shared database. This data is also archived for delivery to upline users (NAVAIRSYSCOM, 1997, p. 4).

3. Life Usage Index (LUI) Module

This module calculates the time remaining on components life limited components on the aircraft, such as engines. The LUI can be calculated despite gaps in the data which may occasionally occur (NAVAIRSYSCOM, 1997, pp. 4-5). This method of calculation is much more accurate than manually tracking flight hours logged on life limited components. It also allows for the degree of wear the components received as recorded on the DSU.

4. Structural Appraisal of Fatigue Effects (SAFE) Module

The F/A-18 contains seven gauges throughout the aircraft structure which measure fatigue on the aircraft. These "strain" gauges take ten samples per second as they measure the forces imposed on the aircraft during flight, and are then transmitted to the mission computer. The mission computer filters and records the peak readings on the DSU (NAVAIRSYSCOM, 1997, p. 5). A measure known as Fatigue Life Expenditure FLE is calculated from the strain gauge data using the SAFE module. Data from FLE can accurately show the true "aging" of an aircraft by measuring the cumulative effects of flying forces on the airframe which may differ according to the type of sortie flown. Similar to LUI data, FLE measures show a much truer age of an aircraft than simply adding flight hours accumulated by the aircraft. The SAFE module will provide FLE calculation at the squadron, greatly increasing the availability of this information over the current process.

5. Aviation Performance Monitoring System (APMS) Module

This module incorporates a statistical analysis package under development by NASA for use in commercial aviation. Statistical analysis over a range of flights and parameters selected by the user is possible with APMS. The information is displayed in histograms which permit drill-down analysis of underlying events. A search capability also exists to find specific occurrences in a series of events. Flight data can also be used to create animation of the actual flight. Another feature automatically detects the occurrences of special events. (NAVAIRSYSCOM, 1997, pp. 5-6)

6. Help Request Documentation (HRD) Module

This application will drastically improve the information access of the maintenance technician, and allow for faster processing of NAMDRP reports. In this module is the capability to link squadron maintenance personnel with all other maintenance levels, including the Original Equipment Manufacturer (OEM). Technicians will also be able to access Interactive Electronic Technical Manuals (IETM), computer based training (CBT) modules, and process NAMDRP reports automatically. All of these capabilities will be available through a workstation in the maintenance workcenter, or at the aircraft with the use of a hand-held computer (NAVAIRSYSCOM, 1997, p. 6).

The Portable Electronic Display Device (PEDD) will be the hand-held link through which technicians will have real time access to maintenance information resources, including interactive communication with all other maintenance levels, while they are conducting maintenance on the aircraft. Technical data provided by IETMs will be specific to individual aircraft. Technical drawings and wiring diagrams the technician will use during a maintenance action will be the actual wiring of that particular aircraft. Incorporated technical directives will reflect any configuration changes to the aircraft in the electronic technical publications. Quality assurance personnel will have a digital audit trail by which they can review the steps accessed in the technical publication by the technician for any maintenance action.

All of these capabilities will improve the quality of maintenance by giving faster access to better information than is currently available. Real time technical assistance and electronic technical publications which are always current, provide information accuracy to the technician at unprecedented levels.

The full capability of the AME system is greater than the sum of its parts. The true capability of the system cannot be seen just by a brief module-by-module description. The next section will provide a conceptual description of how the AME system will enhance the maintenance process, and provide greater decision making information to the MMCO.

C. CONCEPT OF OPERATIONS AT THE OMA

The author was given the opportunity to visit the F/A-18 manufacturing site at the Boeing facility in St. Louis, Missouri; and to see demonstrations on portions of the Hornet AME system applications under development. The following concept of operations is based upon capabilities which were demonstrated and discussions with members of the AME program for the F/A-18.

1. Post Flight Debrief

The description of the AME system in an operational environment begins when an aircraft returns from a sortie. A post flight debrief by the pilot conducted in maintenance control immediately after engine shut down is standard operating procedure in Navy squadrons. Aircraft preparation for the next sortie begins at this point. Typical cyclical operations aboard an aircraft carrier require that this turn around cycle be accomplished within 90 minutes. Fueling, arming, repair actions and pre-flight inspections must be accomplished within this narrow time frame if the flight schedule is to be maintained. An inability to meet this time constraint will result in a missed scheduled sortie if a spare aircraft cannot be made available. Therefore, it is important that a thorough, concise, accurate debrief by the pilot be accomplished immediately upon return from the previous mission.

The debrief is carried out between the pilot and the maintenance control chief. The MMCPO and MMCO are usually, but not always, on the periphery of this debrief. The pilot will briefly evaluate the aircraft performance from the previous flight, and describe any maintenance discrepancies, or "gripes", which occurred during the flight. Any discrepancies which render the aircraft unsafe to fly must be repaired prior to its next launch. Aiding the pilot in this debrief process are aircraft malfunction codes recorded by the pilot from a cockpit display prior to engine shut down. These three digit numerical codes are indicators to aid in the fault isolation of any maintenance discrepancies, and fall into one of three classifications; BIT (Built-in Test), BOA (BIT Operational readiness test Accumulated BIT), and BLIN (BIT Logic Inspect). For ease of discussion, all types of aircraft malfunction codes will be referred to as BIT codes. The AME system will take the current debrief process one step further.

The key to the success of the AME system exists in automation of the debrief process. Up to this point, the post flight debrief has consisted of verbal communication and the manual recording of BIT codes from aircraft displays. The second part to the debrief process is the downloading of flight recorder data from the DSU after each flight into the AME system. Part of the data automatically captured will be BIT codes which will be filtered through an expert system. An expert system is a computer program which can make decisions and offer solutions similar to what a human expert would provide (Heizer and Render, 1996, p. 747). This expert system will have the capacity to learn over time which diagnostic codes are typically erroneous, and filter them out of the diagnostic process. Expert system diagnostics will offer a recommended repair action or troubleshooting strategy base upon the automated inputs from the DSU and the manual inputs generated by maintenance control from the pilot debrief. It is at this point that maintenance control would have an accurate estimate on the necessary repairs, and their accompanying time, personnel and support requirements. The MMCO and the production staff would quickly have information required to determine a course of action based upon time, personnel and support constraints.

2. The Maintenance Action Process

The information affecting the assignment of maintenance actions and their prioritization in the production schedule will be more complete with the AME system. Production control decision makers will have an immediate determination of material, support equipment and personnel requirements required for a repair action from the expert system diagnostic solution. Currently, this information is predominately determined at the workcenter level, which leads to repair forecast inaccuracies. Links to Supply and AIMD through NALCOMIS will provide real time support capability. Automated tracking of components would greatly enhance the accuracy of support information. The ability to automatically track components will be discussed in a later section.

The determination of personnel production capability will be more accurate in the AME system as well. Electronic Training Jackets (ETJ) for maintenance technicians, now under development, can be incorporated into AME. This technology can be used by production control personnel to readily determine the production capability from a qualification standpoint of a workcenter. Additionally, a computer based muster report software application, if available would provide immediate visibility of personnel availability to production decision makers.

Once production control has determined the workcenter assignment for the repair action and its priority in the production schedule, the maintenance action will be transmitted electronically via NALCOMIS to the assigned maintenance workcenter. Maintenance technicians could review the recommended troubleshooting and maintenance procedures through the IETMs. This process will be faster electronically since technicians will not have to search for the appropriate work package through several cumbersome paper volumes of technical publications. If necessary, the technicians could quickly review CBT modules for maintenance actions which may not occur regularly. It should be noted at this point that the maintenance technician is ultimately in control of the troubleshooting and maintenance procedures to be taken. The expert system diagnostics which incorporate automated and manual malfunction inputs provide a recommended course of action. The experience of the technicians will determine to what extent this recommendation should be followed. The assigned work package and associated CBTs are then downloaded into a PEDD from the personnel computer in the workcenter. With the PEDD, the maintenance technicians have all the technical information they need at the aircraft.

Use of the electronic technical manual work packages downloaded into the PEDD will also provide an electronic audit trail for the QA personnel. Quality Assurance will be able to see which pages in the work package were reviewed by the technician. This audit capability will be especially useful for infrequent maintenance actions, or complicated troubleshooting procedures. When the maintenance action is completed, the maintenance action form can be quickly completed using a "point and click" format. Certain fields in the form will be automatically filled in depending on the type of maintenance action. This will ensure accuracy in the classification of discrepancies such as not mission capable, partial mission capable, or full mission capable. Automatic calculation of maintenance hours and requisition information will improve reporting accuracy and speed the documentation process.

3. Configuration Management and Production Planning

The strength of the AME concept is the automation of data input, processing and extraction. The current configuration management process is plagued by inaccuracy, large volumes of records which are manually updated, delays in processing, and frequent requirements to verify and re-verify the incorporation of TDs. In the AME system, aircraft and engine logbooks, equipment history records for specified components, aircraft weight and balance records, and TD incorporation records could all be stored as electronic logsets. Updates to an aircraft data file stored in the shared database, would automatically be annotated in the applicable logsets. Processing of aircraft status reports, engine transaction reports, NAMDRP, and TD incorporation status reports could all be done automatically.

One challenge of configuration management in an automated environment is tracking components as they are removed from aircraft, inducted through supply, repaired at AIMD or higher levels of maintenance, and eventually returned to service. Manual entry of component serial numbers subjects the system to human error. Implementation of automatic identification technologies will overcome the problems associated with the manual tracking of components. Smart Buttons are an example of commercially available identification technology which could feasibly be used to automatically track aircraft components. These devices are as small as a screw head, contain 128 KB of erasable memory, and can be attached by adhesives (Carlberg, et al., 1997, p. 30).

The automated capture and storage of all aircraft data in a shared database enables comprehensive production planning to be accomplished by the MMCO and maintenance control personnel. The AME application modules working together will provide maintenance managers with production planning information that is accurate and provided in a real time format. When an aircraft comes due for a scheduled inspection, the planner will be provided with a recommended list of which technical directives to incorporate during the inspection, in addition to other outstanding maintenance discrepancies. Currently, this planning is accomplished by manually researching aircraft logbooks, discrepancy books and technical directive lists. This research is time consuming and prone to error, leading to inefficient use of maintenance resources.

D. POTENTIAL AME BENEFITS

The automated maintenance environment concept offers wide-ranging benefits throughout the maintenance management process. Automated data capture and shared databases provide an access to accurate information which can support intelligent, timely decisions. The AME concept improves upon the current NALCOMIS system in all of the five decision areas for the MMCO.

1. Personnel Management

The personnel management function will be improved through the combined use of electronic training jackets, expert system diagnostics, computer based training, and interactive electronic technical manuals. Production capability from a personnel perspective will be visible to production planners by accessing maintenance qualifications relevant to a specific maintenance action. This will allow for more realistic production forecasting. Quality of maintenance and trouble shooting accuracy will be enhance by giving the maintenance technician access to expert system diagnostic recommendations, computer based training modules and aircraft specific technical diagrams. Access to this information will be available at the maintenance site by using the portable electronic display devices. Additionally, the use of IETMs will allow for the review of maintenance actions through the electronic audit trail recorded by the system. This capability will help identify maintenance procedure weaknesses which can be addressed through periodic training, making the training program more effective.

2. Support

The automatic capture of data, component tracking and reports generation will make support information timely and reliable. Reliable support information readily available will improve time sensitive decision making such as cannibalization actions. Reductions in cannibalization through a more efficient information system will reduce the number of unnecessary cannibalization decisions. Maintenance resources, in turn, will be more efficiently applied.

3. Configuration Management

The complexity of military aircraft and the numerous changes which occur on these aircraft throughout a lifecycle demand an automated configuration management system. The AME system provides the needed level of automation in all configuration management functions; TD incorporation, component tracking, parts kits tracking, scheduling, reports processing and accounting. The information accuracy and the speed of its processing will bring the configuration management program to its intended degree of accuracy. Enhanced aircraft performance through timely configuration changes will result in lifecycle cost savings and improve safety in aircraft operations and maintenance.

4. Reports Processing

The administration time spent in preparing, screening and tracking of the numerous varieties of reports which flow through the maintenance department will be greatly reduced through automation. This reduction in administration time will increase time available to analyze maintenance and aircraft performance tendencies. Increased analysis in these areas will increase the knowledge and understanding of maintenance processes. Innovative ideas are one result in gaining a higher level of understanding about a process.

5. Production Scheduling

Currently the production scheduling process is reactive to dynamic conditions, is based on the personal experience of the MMCPO or MCPO, and does not tend to take a long term view. The consolidated database of the AME and its combination of applications will enable production planners to make decisions based on accurate information. Increased access to timely information and a reduction in administrative burdens will allow for better intermediate and long term planning. Improvements in planning decisions at the organizational level will have direct and long lasting effects on the aircraft lifecycle costs.

6. Proven Benefits: The Aviation Maintenance Integrated Diagnostics Demonstration (AMIDD)

In a demonstration conducted at VMFAT-101 from August 1995 through September 1996, several AME base concepts were tested. VMFAT-101 is a F/A-18 Fleet Readiness Squadron with 43 total aircraft representing all four models of the Hornet. The demonstration consisted of the use of expert system diagnostics based on flight record data retrieved from the DSU, the use of IETMs and PEDDs, automated tracking of serialized components, and the use of a graphical user interface with "point and click" capability. (Carlberg, et al., 1997, pp. 1-2)

The results of the demonstration verified many projected AME benefits. One highlight of the demonstration was a 50% reduction in components sent to the IMA in which no fault could be found. This result lends supporting evidence to improvement in the quality of maintenance through the use of expert system diagnostics. Additionally, maintenance technicians found that the use of IETMs and PEDDs improved maintenance actions through error reduction and reduction in repair time. Lastly, automation of MAF form filling functions reduced the error rate in processing of these forms from 27% to 9%. (Carlberg, et al., 1997, pp. 19-21) Further testing of the AME system will occur during OPEVAL for the F/A-18 E/F, scheduled in April 1998.

E. POTENTIAL RISKS

Transition to the automated maintenance environment will bring innovative changes to maintenance processes in repair, administration and management.

Large projects which require significant levels of change in a large organization such as the Navy involve implementation risks. An awareness in the degree of risk involved in a project can help in planning to minimize risk. It is not within the scope of this thesis to do a comprehensive risk assessment on the implementation of AME. A general discussion will be given highlighting areas of risk to be considered.

Certain cultural aspects may bring resistance to acceptance of AME concepts. The automation of data entry and processing will lessen the opportunity to manipulate data. Readiness reporting is one example. Aircraft readiness reports submitted to the Wing each day can be adjusted to present maximum readiness figures for a given time when the report is due. This practice stems from competitiveness amongst air wing squadrons, to an honest attempt in presenting "the real" readiness picture to the Wing (Allen, 1988, p. 33). There will be wariness at the OMA in knowing upline activities will have unfiltered readiness information almost as quickly as the MMCO. The culture within maintenance activities is to present the best readiness picture possible, at all times. A similar resistance may initially be present within the squadron workcenters since their production performance can be more closely monitored. Skepticism towards automation may be present as manual tasks are replaced by technology. Upline maintenance managers will need to be thoughtful in their use of new information AME will make possible.

Training in the use of AME applications will alleviate much of the resistance that automation may bring. Showing the users improvements in their job performance and overall squadron performance will gain acceptance for the new system. A lack of training will only lead to confusion and a desire to keep things the same. Implementation training will need to occur at all levels of the maintenance organization to minimize these cultural risks.

Risks in organizational structure are another threat to the successful implementation of AME. Application of AME concepts cut across many Navy activities which will affect its implementation. Policy changes, funding and authority all have issues which need to be addressed. The stovepipe structure of the Navy organization may lead to power struggles which can affect the efficient implementation of AME. A willingness to work through these organizational boundaries will be necessary. Conscientious use of integrated product teams will be required to overcome the risks presented in the organizational structure.

Large projects involve greater degrees of risk. Projects which are highly structured will have lower risk (Applegate, McFarlan and McKenney, 1996, p. 626). Implementation of the AME throughout Naval aviation will be a large undertaking. The risks incurred due to project size can be minimized if its implementation remains highly structured and well planned. The benefits of AME implementation will far outweigh its risks provided an awareness, assessment and reduction of the risks involved is conducted.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. NALCOMIS is Not an Effective MMCO Information System

The MMCO and other decision makers in the OMA, require information system output presented in a usable format that can quickly be processed for a maintenance management decision. NALCOMIS fails to meet this standard. NALCOMIS is a data transaction system more than an information system. The reports produced by NALCOMIS are not conducive to rapid interpretation. Additionally, NALCOMIS data accuracy is vulnerable to errors stemming from manual data input. There is an opportunity to improve MMCO information in each of the five decision areas.

Production decisions regarding workload management can be improved by providing personnel production capability to maintenance control. Production bottlenecks can be avoided if personnel availability and capability is accessible through NALCOMIS. Support availability data is currently susceptible to time lags and inaccuracy from manual data entry. Automated data capture would improve the reliability and usefulness of support information.

Automation of configuration management processes and maintenance administrative processes would improve the productivity and effectiveness of the maintenance decision makers. Removing administrative burdens allows increased time for analysis of aircraft maintenance issues and processes. Increased understanding in these areas can lead to improved aircraft maintenance decisions, reducing aircraft lifecycle costs.

Lastly, the MMCO must make intermediate and long term scheduling decisions based upon experience and the combined human resources of the maintenance control staff. The availability of a computer based decision support system would enhance production scheduling decisions. Increased efficiency of these decisions would provide higher readiness through higher maintenance yield.

2. Automated Data Capture is Required For Optimal Maintenance Management

The Maintenance Material Control Officer is best served by an information system which can provide decision support in a time sensitive environment. The information provided must also be accurate. Confident decision making relies upon information sources which can be trusted. Secondly, the information must be accessible and delivered in an easily interpreted format. Decisions at the OMA must often be made in time frames measured in hours, sometimes minutes. Maintenance managers at this level do not have the luxury of time to search for desired information, or thoroughly analyze mountains of data.

Automation is the key to many of the MMCO information requirements. Automated data capture improves information accuracy. The automation of reports processing, tracking and form filling will reduce administrative burdens which consume valuable time. Complex activities such as configuration management, are simplified by the use of automation technologies. The automation of data handling and routine administrative tasks will add value to the maintenance management process by allowing more time for decision making and analysis.

3. The Automated Maintenance Environment Fulfills Decision Support Requirements

The continued development of NALCOMIS will yield improved capabilities over the current system. Incorporation of configuration management functions should result in improved configuration accounting and accuracy. The addition of ECAMS functions will consolidate computer hardware requirements at the OMA, and continue to provide life usage information automatically captured from aircraft flight data recorders. Also, providing NALCOMIS with a graphical user interface will speed transaction processes by reducing the number of keyboard entries. However, the proposed enhancements to NALCOMIS, including those in development, will fall short in fully providing decision support to the MMCO.

The Automated Maintenance Environment is a concept under development which capitalizes on the benefits of automated data capture and modular systems applications. Full adoption of AME initiatives under development will address the shortcomings of NALCOMIS as an information system. AME will fulfill the decision support requirements of the MMCO and the production control staff. Quality of maintenance will also significantly improve through the use of expert system diagnostics and real time, aircraft specific, technical information. Automation will greatly reduce much of the administrative requirements of the current system.

The AME system will reduce the lifecycle costs of an aircraft and improve aircraft availability. Improvements in information quality provided to OMA maintenance managers, supervisors, and technicians will produce better maintenance decisions. These decisions will result in more efficient use and allocation of maintenance resources. The cumulative effects of better decisions on a daily basis at the OMA will produce savings in maintenance costs. AME will provide accurate decision support to all levels of maintenance at a greater rate than the current system. Enhanced information velocity will quicken the maintenance process, resulting in reduced maintenance down times. A reduction in down time increases aircraft availability.

B. RECOMMENDATIONS

The continued development and full implementation of the AME initiative will have a profound effect on Naval Aviation maintenance processes. The incorporation of information technology solutions within the AME concept will produce logistical efficiencies that manual processes will not attain. Advanced technology aircraft should be supported by systems which can maximize this technology. The personnel tasked with the maintenance and management of these complex systems deserve information which will allow them to maximize their talents. Full support to the AME initiative is recommended.

Based on the research conducted in the course of this thesis, following recommendations and needs for further research are proposed:

1. Implement AME and Develop Measures of Effectiveness

The benefits of implementing AME concepts cannot be fully understood unless standards are established to measure overall performance. Research which identifies measures of effectiveness for the AME would potentially help identify opportunities for improvement in development of the AME.

2. Adopt Naval Aviation Maintenance Policy Requiring Automated Data Capture

A Naval aviation maintenance policy change requiring automated capture and processing of aircraft data would be one step in carrying forth the AME initiative. Research will be needed in the areas of: implementation, funding, and training requirements in support of this policy. Further research could also be conducted measuring the effects of automated data capture on the NALDA databank.

3. Initiate Maintenance Manager Training in the Application of Information Technology to Aviation Maintenance

Personnel who are making aviation maintenance decisions need to know how to use existing technologies to aid in making better decisions. Training of this nature will become more important as AME initiatives now under development reach the fleet. Research which investigates training program requirements will be useful in the development of a comprehensive training plan for maintenance managers.

4. Analyze the Maintenance Control Process

The maintenance management processes in Naval aviation have been successfully refined over several years. However, information technology is bringing rapid changes in management processes. Analysis of the maintenance control process could provide insight on innovative ways to improve production performance using new technologies.

5. Investigate Further Application AME of Concepts

The AME initiative has potential applications in areas outside of aviation maintenance. Adoption of AME concepts in other areas such as ship maintenance offers opportunities for further research. Studies investigating potential economies of scale made available by expanding the application of AME would also be valuable.

APPENDIX. RESPONSIBILITIES OF THE MMCO

The OPNAVINST 4790.2F Volume I, paragraph 11.6.1, lists the following responsibilities of the Maintenance Material Control Officer:

a. Coordinate and monitor the department workload.

b. Maintain liaison with supporting activities and the supply department to ensure requirements and workload are known and satisfied.

c. Control daily workload and assign work priorities to ensure efficient movement of components through the department. Where physically possible, maintenance/production control will have intercom capability, independent of telephones, with all work centers.

d. Prepare required MIs (maintenance instructions) to ensure adequate communication and control.

e. Review MIs, planned maintenance system (PMS) publications, and local maintenance requirements cards and ensure compliance.

f. Ensure the full capability of the department is used in supporting the department workload.

g. Maintain TD control procedures for the department. Initiate TD compliances, ensure required material is ordered, and schedule timely incorporation of TDs.

h. Review monthly MDS (maintenance data system) reports and NALCOMIS reports/inquiries to ensure effective use of personnel, equipment, and facilities.

i. Maintain aircraft logs, associated equipment and SE records, including weight and balance data (in conjunction with the operations department), and inventory logs.

j. Furnish technical advice and information to the supporting supply department concerning the identity and quantities of supplies, spare parts, components, engines, and propellers to accomplish assigned workload.

k. Plan material requirements to support the department workload.

l. Establish and operate tool rooms in support of the Tool Control Program (TCP).

m. Review the allowance lists for adequacy, and initiate action for revision as required.

n. Keep the AMO/AAMO advised of the overall workload and material situation as it affects the department.

o. If operating NALCOMIS OMA, the MMCO will:

(1) Coordinate and monitor NALCOMIS in relation to the OMA maintenance evolution.

(2) Establish liaison between the supply activity and the OMA to ensure all automated NALCOMIS supply processes are used and streamlined.

(3) Ensure aircraft discrepancy books are validated against the data base reports.

(4) Ensure all subsystems within the scope of NALCOMIS OMA (assets, maintenance, logs and records) are kept updated.

Paragraph 11.6.2.1 lists additional responsibilities, including:

a. Submit MAF work requests to the supporting IMA for those functions beyond the capability or responsibility of the activity.

b. Hold a planning meeting in advance of each phase inspection.

c. Attend the monthly maintenance meeting held by the supporting IMA.

d. Establish procedures for controlling cannibalization.

e. Ensure functional checkflights are conducted as required.

f. Establish procedures to monitor the Subsystem Capability Impact Reporting System and such other reports as required.

g. Ensure the Equipment Master Roster is kept current to reflect those inventory and status changes that occur during the reporting period.

h. Ensure divisions assign qualified personnel for the completion of scheduled maintenance and inspections.

i. Maintain close liaison with QA, particularly when major components are changed. Maintenance control shall take the initiative to inform QA when such changes occur.

j. Provide pilots and aircrews with a record of aircraft discrepancies and corrective actions for the preceding ten flights of the aircraft.

LIST OF REFERENCES

Alkon, R., "Who's On First?". *Approach MECH.* July-August 1996.

Allen, R. *NALCOMIS/OMA: Functional Considerations For Automatic Organizational Maintenance Activities.* Master's Thesis. Monterey, CA: Naval Postgraduate School. March 1988.

Applegate, L. and F. McFarlan and J. McKenney. *Corporate Information Systems Management Text and Cases (Fourth Edition).* Chicago, IL: Irwin. 1996.

Barnes, R. and J. Harding. *From Greaseboards to Gigabites: A Comparative Analysis of Naval Aviation and Commercial Airlines Maintenance Scheduling Methods.* Master's Thesis. Monterey, CA: Naval Postgraduate School. December 1995.

Blanchard, B. *Logistics Engineering and Management (Fourth Edition).* Englewood Cliffs, NJ: Prentice-Hall. 1996.

Carlberg, J. and Le Beau, R. and Post, J. and Blair H. *Aviation Integration Diagnostic Test Report (Draft).* Bethesda, MD: Carderock Division NAVSURFWARCENT. November 1997.

Chief of Naval Operations. *The Naval Aviation Maintenance Program (NAMP),* OPNAVINST 4790.2F (CD-ROM). Patuxent River, MD: Naval Aviation Maintenance Office. 1995.

Christensen, D. and M. Pasadilla. *The Design of a Prototype personal Computer Database For the Expert System Advisor For Aircraft Maintenance Scheduling (ESAAMS).* Master's Thesis. Monterey, CA: Naval Postgraduate School. December 1991.

Gray, D. "Airworthy: Decision Support for Aircraft Overhaul Maintenance Planning." *OR/MS TODAY.* December 1992.

Heizer, J. and B. Render. *Production and Operations Management: Strategic and Tactical Decisions (Fourth Edition).* Upper Saddle River, NJ: Prentice-Hall. 1996.

McCaffrey, M. *The Feasibility of Implementing an Expert System for Aircraft Maintenance Discrepancy Scheduling With the Naval Aviation Logistics Command Management Information System (NALCOMIS).* Master's Thesis. Monterey, CA: Naval Postgraduate School. September 1985.

Naval Air Systems Command. *Preliminary Project Plan For the F/A-18 AME Software System.* China Lake, CA: Naval Air Warfare Center Weapons Division. September 1997.

Yates, F. *Risk-Taking Behavior.* West Sussex, England: John Wiley and Sons Ltd. 1992.

BIBLIOGRAPHY

Allen, D. and W. McSwain. *Naval Aviation Maintenance Decision Support System.* Master's Thesis. Monterey, CA: Naval Postgraduate School. March 1989.

Carlberg, J. and Le Beau, R. and Post, J. and Armijo, M. *Automated Maintenance Environment Cost/Benefit Report (Draft).* Bethesda, MD: Carderock Division NAVSURFWARCENT. December 1997.

Bearden, B. *The Bluejackets' Manual (Twenty-First Edition).* Annapolis, MD: United States Naval Institute. 1990.

Stone, M. *Development of a Knowledge Base for Use in an Expert System Advisor for Aircraft Maintenance Scheduling (ESAAMS).* Master's Thesis. Monterey, CA: Naval Postgraduate School. March 1991.

INITIAL DISTRIBUTION LIST

No. Copies

1. Defense Technical Information Center..2
   8725 John J. Kingman Rd., Ste 0944
   Ft. Belvoir, VA 22060-6218

2. Dudley Knox Library...2
   Naval Postgraduate School
   411 Dyer Rd.
   Monterey, CA 93943-5101

3. Professor William J. Haga, Code SM/Hg...1
   Department of Systems Management
   Naval Postgraduate School
   Monterey, CA 93943

4. RADM Donald R. Eaton, USN, RET, Code SM/Et.....................................1
   Department of Systems Management
   Naval Postgraduate School
   Monterey, CA 93943

5. Assistant Commander for Logistics (AIR-3.0)..1
   Naval Air Systems Command HQ
   47033 Mcleod Rd Unit 8
   NAS Patuxent River, MD 20670-1625

6. CAPT James Godwin 1
   Naval Air Systems Command
   47123 Buse Rd Unit IPT
   Patuxent River, MD 20670-1547

7. CDR Mike Hardee...1
   Aircraft Maintenance Programs/Policies
   Commander Naval Air Forces Pacific Fleet
   Naval Air Station
   North Island, CA 92135

8. LT Matt Herl...1
Naval Air Systems Command (PMA-265)
47123 Buse Rd Unit IPT
Patuxent River, MD 20670-1547

9. Mr. Jim Carlberg...2
Carderock Division
Naval Surface Warfare Center
Code 2053
Bethesda, MD 20817-5700

10. LCDR Bruce Brosch..2
Naval Air Systems Command (PMA-265)
47123 Buse Rd Unit IPT
Patuxent River, MD 20670-1547